EDITION 2

Assembly Manual

Morse RTTY Decoder K-6339

DICK SMITH ELECTRONICS
PTY LTD

KIT

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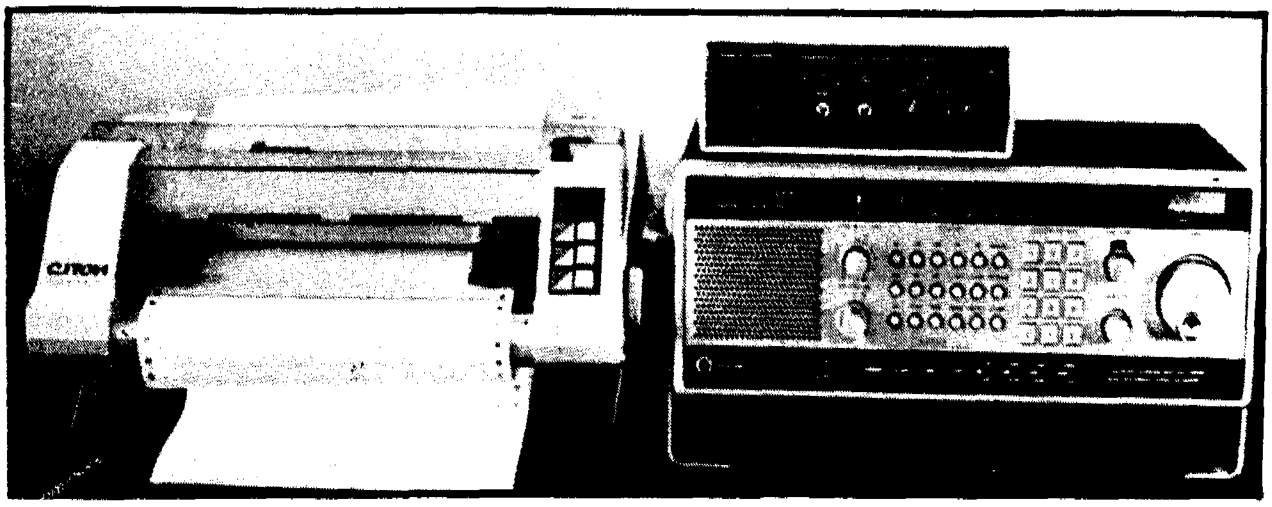

This project is hooked up between the audio output of a receiver and a dot matrix printer. It will decode and print out any Morse or radioteletype transmissions you tune in. If you don't have a computer - here's the modern way to get into "electronic" RTTY and Morse reception. If you do have a computer, free it up for other uses!

MANY READERS will be familiar with the concept of using a personal computer to decode and display Morse code or radioteletype (RTTY) information from a shortwave radio receiver. Various interfaces and some quite clever software have been published for this purpose in the past (such as the AEM3500 "Listening Post" by Tom Moffat) and most designs have proved very popular. The greatest disadvantage of using this method however, is that the computer can't be used for any other tasks whilst you are monitoring the airwaves.

This project, from the R&D division of Dick Smith Electronics, overcomes the problem by putting the decoder, computer and software all in one integrated unit and using a parallel printer as the output device. the unit is constructed on one single-sided printed circuit board which holds the majority of components, and housed a smart plastic instrument case. It is powered from a low-cost dc plugpack.

The decoder is comprised of two main sections, analogue and digital, as can be readily seen from the circuit diagram over the next page. The analogue section includes both narrow and wide filters for RTTY and a tone detector/demodulator circuit based around the popular XR2211 IC. The digital section is based around a Z80 microprocessor running at 4 MHz with a minimum number of support chips to help reduce cost and complexity.

The front panel switches on the decoder allow a choice between Morse code or a variety of standard RTTY baud rates. The printout is formatted with the automatic insertion of carriage return/line feeds that take place after either 40 or 80 received characters. Carriage returns and line feeds that are decoded during reception are executed as they are received so that, in the case of standard RTTY transmission, the original formatting of the transmitted text is preserved.

The Morse code decoding program self-tracks over a wide range of transmission speeds, from very slow, around 5 words per minute (WPM), to more than 40 WPM. As the tone of a Morse signal may vary in pitch from one source to another, a control is provided to tune the tone detector over a range from 800 Hz to 3 kHz. RTTY polarity can be inverted if required and two RTTY frequency shift options are available: 170 Hz using the tone pair of 2125/2295 Hz as commonly used by amateur stations, and 850 Hz using the tone pair of 2125/2975 Hz as often employed by commercial stations.

Construction

The pc board for this project has a lot of very fine tracks and quite a high track density. Before starting construction, a good visual inspection should be made to check that all holes are drilled correctly and there are no shorted or broken tracks.

Commence construction by first fitting all the wire links. There are quite a few of these and you will need to pay careful attention to the component overlay. Make sure that none of the links contact one another. After fitting all the links, you should solder all the pc board pins in place. These are used to terminate all the flying leads from the pc board and there are quite a few of them. Once all the links and pins are fitted, you can continue construction by fitting all the resistors.

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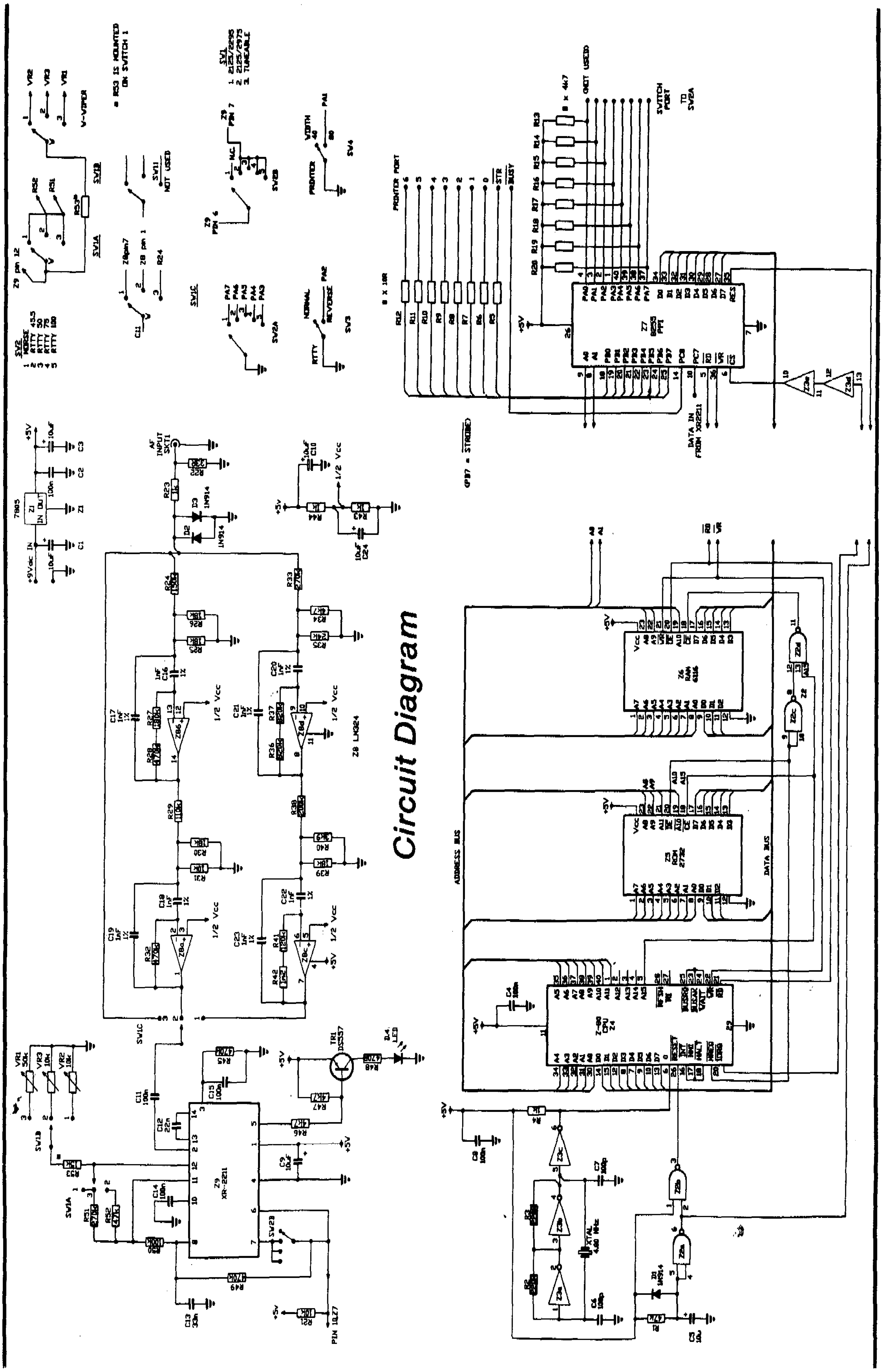
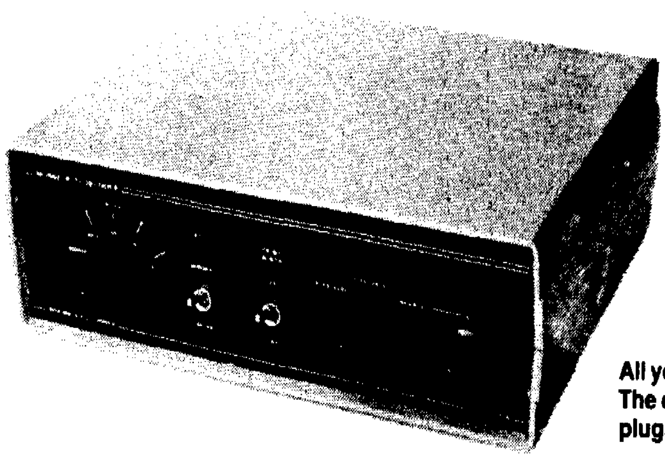
Circuit Diagram





All you need is a shortwave receiver, the decoder and a printer! The decoder is housed in a smart plastic instrument case and plugs into the auxilliary audio output of your receiver.

CIRCUIT OPERATION

The demodulator section of the project is based around an Exar XR2211 FSK demodulator IC. For those of you who are interested in the operational details of this device, a data sheet was published in the October 1985 issue of AEM and we have also published a number of projects based around the chip in recent months.

Audio from the external speaker jack of the receiver is applied to the input socket of the unit where it is attenuated by the network R22 and R23 and clamped by the back-to-back diodes D2 and D3.

The project provides for two different RTTY shift frequencies and each of these has a separate bandpass filter to treat the incoming signal from the receiver.

Reference to the circuit diagram will show that the filters are constructed using all four sections of an LM324 quad op-amp. Two sections are used for each filter and switch SW1 selects which filter output is used as the signal source for the XR221 demodulator. There is a third position of SW1 which bypasses the filters altogether and this is used for the "tuneable" mode.

The 170 Hz shift filter employs the Z8c and Z8d sections of the LM324 and has a bandwidth of about 480 Hz with a centre frequency close to 2200 Hz (it's set at 2208 Hz, to be exact). The 850 Hz shift filter uses Z8a and Z8b to provide a bandwidth of about 950 Hz with a centre frequency set to 2514 Hz.

In this project, the XR2211 is switched between the tone-detect mode for Morse code reception, and the FSK (frequency shift keying) mode for RTTY reception. Switch SW1a is employed to alter the bandwidth of the XR2211 from wide for 850 Hz shift RTTY, to narrow for 170 Hz shift RTTY. The narrow mode is also the most suitable setting for Morse reception. The centre detection frequency of the XR2211 is determined by the values of the three variable resistors VR1, VR2 and VR3. The two preset trimmers VR2 and VR3 are used for RTTY and VR1, on the front panel, is used for Morse tone detect.

The front panel LED shows when the XR2211 is "in lock" during RTTY reception and will flash in time with the dots and dashes during correctly tuned Morse code reception.

The digital section

The digital section of the project is designed around a Z80 CPU. Clock and reset circuits are provided, as well as 2K of RAM, 4K of ROM and an 8255 three-port programmable peripheral interface (PPI) chip.

When power is first applied to the decoder, a power-on reset signal is generated by the charging of C5 through resistor R1 and is applied to both the CPU and the PPI chips. On reset, the CPU starts to execute the program stored in the 2732 ROM, Z5. The ROM is mapped to occupy address locations from 0000H to 0FFFH. The 6116 2K static RAM, Z6, is mapped to memory locations 8000H to 87FFH.

The only remaining circuitry is that for the clock and the power supply. The clock circuit uses a 4 MHz crystal and two sections of a 7404 hex inverter, Z3, configured as an oscillator. A third section of Z3 is used to buffer the clock signal and drives the CPU clock input directly.

The power for the interface is supplied by a 9 Vdc plugpack. The 9 Vdc is applied to a 7805 three terminal regulator, Z1, which supplies a regulated 5 V to the decoder's circuitry. Two 1k resistors, R44 and R43, are used as a voltage divider to bias the LM324 op-amp, Z8, at half supply for correct operation of the filters.

The software

Upon power up, or when any front panel switch other than SW1 is changed, a carriage return is sent to the printer as an indication that the program is running and the digital section of the decoder is functioning correctly. The software includes provision for a character buffer so that characters are not lost during the printer's carriage returns or printing operations.

In the Morse decoding and speed tracking process, an image is derived of the average length of a Morse code "DIT" (the 'dot' of the dot-dash code). This is used to monitor the actual transmission speed and to generate the spaces between words, which tend to be between two and three "DAH" (or dash) lengths in duration. The frequency that spaces are inserted between words is a function of the current Morse speed. As the automatic speed tracking is dependent on incoming DIT length, slow Morse speeds will slow the speed tracking process down somewhat, purely because there are less DITs over a given period of time. Rapid Morse speeds will allow the decoder's software to lock on to the transmission speed faster for the same reason.

Take special care with the resistors around the filter area as 1% resistors can sometimes be difficult to read and it is easy to make a mistake. If you are in any doubt as to the value of any 1% resistors, use a multimeter to check their value before inserting them. Note that resistor R53 is mounted on the switch SW1 as shown in the wiring diagram.

Resistors R5 to R12 have ferrite beads fitted over their leads. These beads, together with a carefully routed pc board earth track and ground plane, will help to reduce interference from the CPU or printer which may be picked up by the receiver.

When you have fitted all the resistors, you may continue by fitting all the capacitors. Take care with the orientation of the electrolytic types and note that the 100n (0.1 uF) capacitor C4 is mounted on the copper side of the board between the CPU power supply rails. This is done to ensure that the leads of C4 are a minimum length.

Construction can continue with the fitting of the trimpots and the DB25 socket. Once these are installed, you can solder all the semiconductors to the board. Take particular care with the orientation of the ICs as they do not all face in the same direction. Sockets may be used for the CPU, PPI, RAM and ROM chips if desired. It is a good idea to use a socket for the ROM, even if you don't use sockets for the other chips. This will facilitate fitting new or updated ROM chips for possible future software enhancements.

The pc board assembly can now be finished off by fitting any remaining components. When soldering the crystal in place, use the minimum heat for a good joint to avoid any damage.

You can now turn your attention to the case assembly and the interconnecting wiring. The kit supplied by Dick Smith Electronics includes pre-punched and screened case panels so it is a simple matter to mount the switches, sockets and LED. If you are not building the project from a kit, you will need to drill the appropriate holes in the case panels in order to mount the various items.

Mounting the various switches and sockets on the panels will allow you to trial fit them in the case together with the assembled pc board. You will then be able to estimate the

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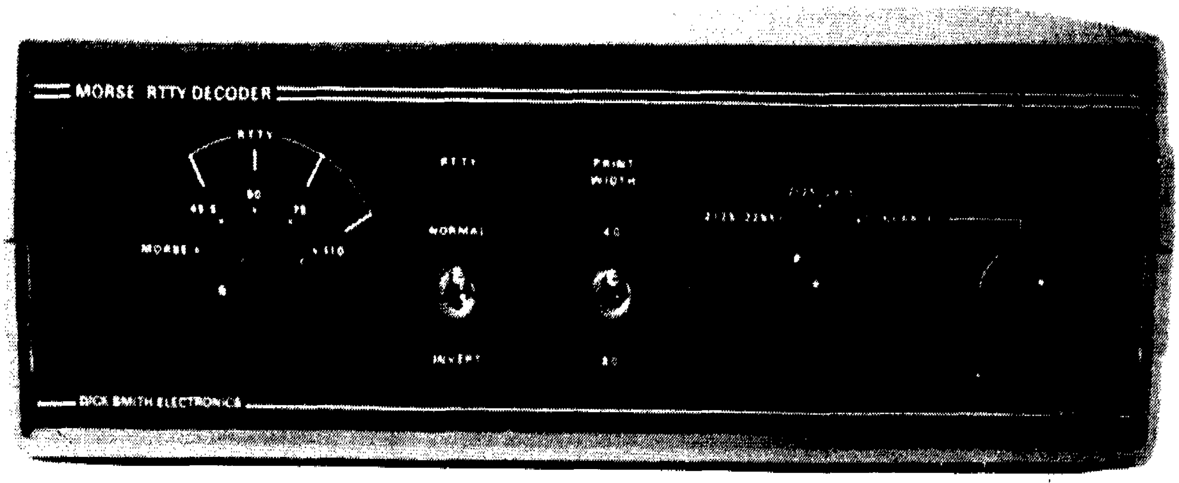


approximate lengths required for the various interconnecting wires so that a neat job can be made of the wiring. Pay very careful attention to the wiring diagram, especially when wiring the two multi-position rotary switches, as these can be a bit confusing. Don't forget to mount resistor R53 on switch SW1.

Alignment and operation

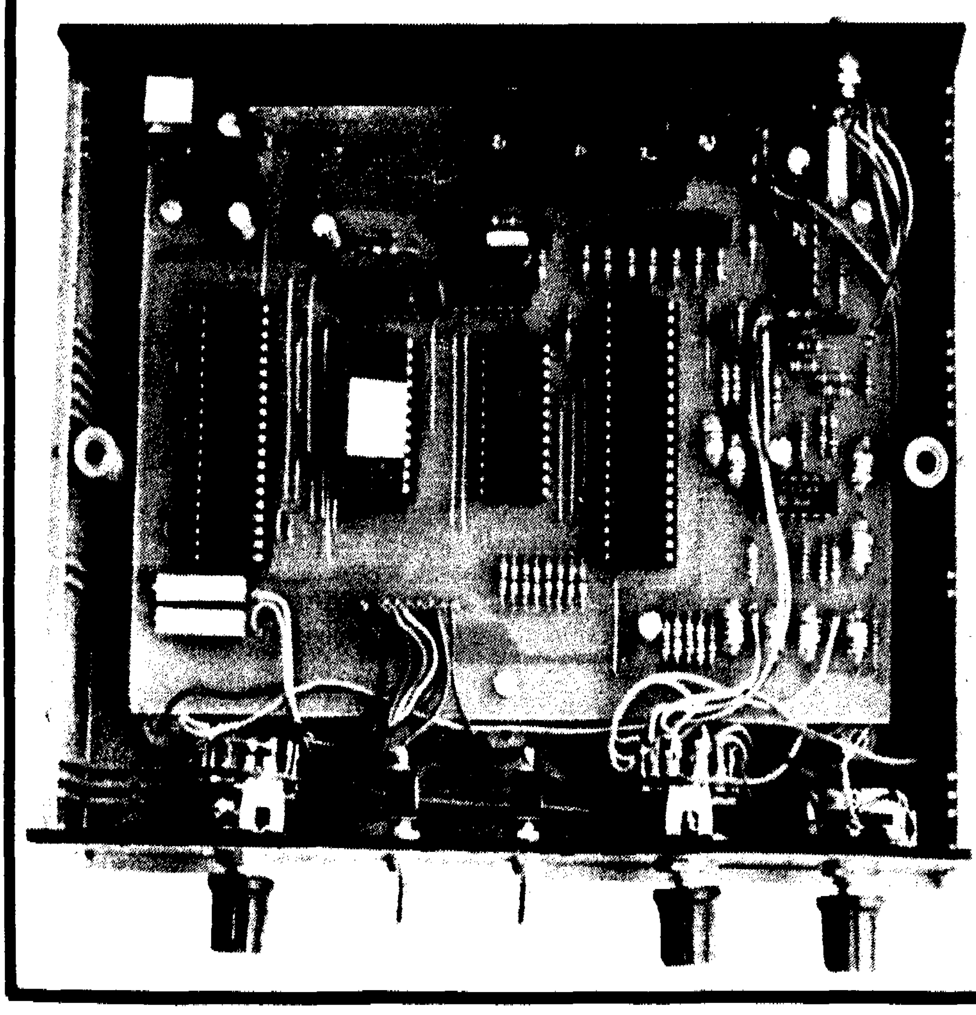
After you have completed construction and made a thorough check of the wiring and soldering, you can connect the plugpack and apply power to the decoder. Special care should be taken when wiring the 3.5 mm jack plug and socket for the power supply as no protection diode has been included in the design. The tip of the plug on the plug pack cable should be connected to the positive side and the corresponding terminal of the panel mounted socket on the decoder should be wired to the "+" pad, nearest the corner of the pc board. If you wish, a 1N4002 diode could be inserted in the flying lead from the positive side of the panel socket for protection. Connect the anode to the socket and the cathode to the "+" pad on the pc board.

When power is applied, the +5 V on-board supply should be checked by measuring at the output terminal of the 7805 regulator. If the +5 V checks out, disconnect the power and connect the decoder to a parallel printer. The decoder is designed to use a standard "IBM" type of printer cable which is fitted with a DB25 plug on one end and a standard "Centronics" style 36-way plug on the other. These cables are readily available from computer accessory outlets as well as Dick Smith Electronics. Power can now be re-applied to the unit and you should observe a carriage return from the printer. This indicates that the digital section of the decoder is functioning correctly.

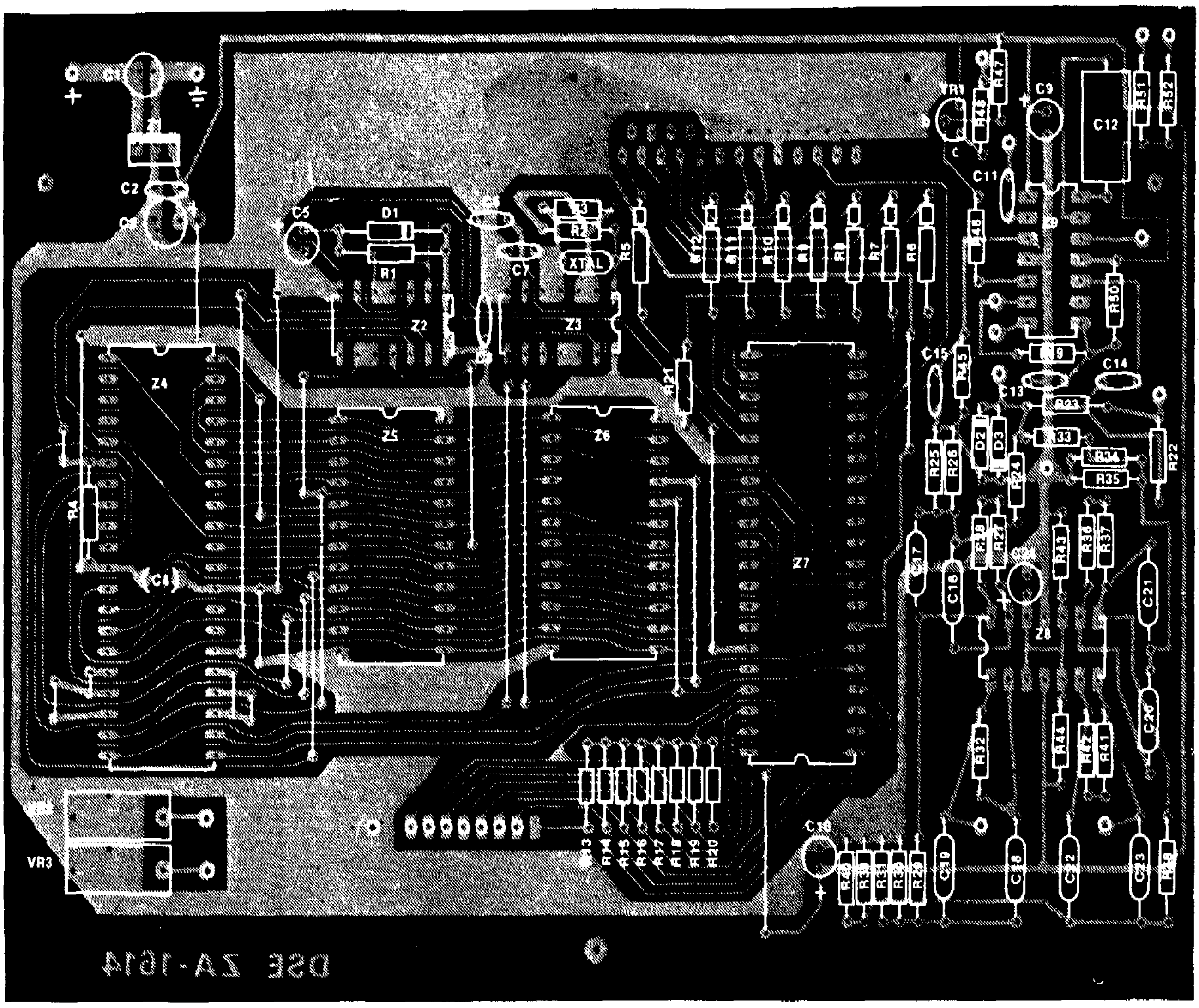
Alignment of the analogue section of the decoder involves setting VR2 and VR3 for the centre frequencies of the RTTY 2125/2295 Hz and 2125/2975 Hz modes respectively. There are a number of ways to go about this and the method you choose will depend to some extent on what test equipment you have available.

The most accurate method of aligning the decoder is to make use of an audio signal generator. If you have an audio generator available, connect it to the audio input socket of the decoder and apply a low level signal at exactly 2208 Hz. Set SW1 to the 2125/2295 position and set SW2 to any of the RTTY baud rates. The output of the XR2211 demodulator IC can now be monitored by observing the signal on pin 6 of the chip with a dc voltmeter (5 V range) or an oscilloscope.

The output of the XR2211 can be found at the crystal end of R21, nearest the DB25 socket. Start by turning both VR2 and VR3 fully counter-clockwise. Now adjust VR2 until a change of state is observed from the XR2211. Observing the same test point, ensure that the signal is high (+5 V) when a frequency of 2125 Hz is applied from the signal generator and low (0 V) when a frequency of 2295 Hz is applied. If this is not the case,



The printed circuit board screws into the bottom half of the case, access to the RS232 connector being via a cutout in the rear panel. The power supply input connector is located on the rear panel at the left and the audio input jack socket is located on the right.



Parts List

Resistors

2 x 47K 1/4 Watt Resistor (R1,R52) ☐
2 x 220R 1/4 Watt Resistor (R2,R3) ☐
4 x 1K 1/4 Watt Resistor (R4,R23,R43,R44) ☐
8 x 10R 1/4 Watt Resistor (R5 - R12) ☐
10 x 4K7 1/4 Watt Resistor (R13 - R20,R46,R47) ☐
1 x 10K 1/4 Watt Resistor (R21) ☐
1 x 33R 1/4 Watt Resistor (R22) ☐
1 x 150K M/Film 1% Resistor (R24) ☐
4 x 18K M/Film 1% Resistor (R25,R26,R30,R39) ☐
1 x 180K M/Film 1% Resistor (R27) ☐
2 x 470K M/Film 1% Resistor (R28,R32) ☐
1 x 110K M/Film 1% Resistor ((R29) ☐
1 x 10K M/Film 1% Resistor (R31) ☐
1 x 270K M/Film 1% Resistor (R33) ☐
1 x 4K7 M/Film 1% Resistor (R34) ☐
1 x 24K M/Film 1% Resistor (R35) ☐
2 x 820K M/Film 1% Resistor (R36,R37) ☐
1 x 200K M/Film 1% Resistor (R38) ☐
1 x 3K9 M/Film 1% Resistor (R40) ☐
1 x 120K M/Film 1% Resistor (R41) ☐
1 x 1.2m ohm M/Film 1% Resistor (R42) ☐
2 x 470K 1/4 Watt Resistor (R45,R49) ☐
1 x 470R 1/4 Watt Resistor (R48) ☐
1 x 100K 1/4 Watt Resistor (R50) ☐
1 x 270K 1/4 Watt Resistor (R51) ☐
1 x 15K 1/4 Watt Resistor (R53) ☐

Capacitors

6 x 10uF 25v Electro Cap (C1,C3,C5,C9,C10,C24) ☐
6 x 100n/.1uF Greencaps (C2,C4,C8,C11,C14,C15) ☐
2 x 100pF Ceramic Caps (C6,C7) ☐
1 x 22n/.022uF MPC Cap. (C12) ☐
1 x 33n/.033uF Ceramic Cap. (C13) ☐
8 x 1n/.001uF Polystyrene 1% Cap. (C16 - C23) ☐

Semi-Conductors

1 x BC557/DS557 Transistor (TR1) ☐
3 x IN914/IN4148 Diodes (D1,D2,D3) ☐
1 x Small Green Led (D4) ☐
1 x 7805 Regulator (Z1) ☐
1 x 74LS132 IC (Z2) ☐
1 x 7404IC (not "LS" type) (Z3) ☐
1 x Z80 CPU IC/D780C-1 IC (Z4) ☐
1 x 2732 Eprom Programmed (Z5) ☐
1 x 6116 Ram IC (Z6) ☐
1 x 8255 PP1 IC (Z7) ☐
1 x LM324 IC (Z8) ☐
1 x XR2211 IC (Z9) ☐

Miscellaneous

1 x 4.0mHz XTAL (XTAL ☐
1 x 4 pole, 3 pos Rot Sw (SW1) ☐
1 x 2 pole, 5 pos Rot Sw (SW2) ☐
2 x SPDT Toggle Switch (SW3,SW4) ☐

ZA 1614 PC Board, 8 x Ferrite beads, 3 x black knobs, Plastic Case, Front Panel, Rear Panel, 3 x Self tapping Screws 1/2 x No. 4, 3 x 6mm Spacers, 1 x DB 25 Socket, 2 x Screws 1/2 x 6 BA, 2 x 6BA Nuts, 2 x 6BA Shakeproof Washers, 3.5mm Jack Socket, R.C.A. Socket, Plug Pack 9Vdc 600mA, 2 x 24pin Dil Sockets, 2 x 40 pin dil Sockets, Rainbow cable, Tinned Copper wire and Solder

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return to a frequency of 2208 Hz and continue turning VR2 clockwise, until another transition occurs and then repeat the test using the 2125/2295 Hz frequencies from the generator.

The procedure for adjusting VR3 is done in exactly the same manner, except that SW1 is set to the 2125/2975 position and the centre frequency from the signal generator should be 2514 Hz instead of 2208 Hz. When both trimpots have been adjusted, you should go back over the alignment and re-check the results.

If you do not have an audio signal generator available, it is possible to use a good quality RTTY signal to align the unit. If this method is used, it is important that the signal accurately complies with frequency and shift standards. For this reason, it is not a good idea to use signals from an SSB receiver as, whilst the shift will be correct, the receiver tuning can vary the actual frequencies applied to the decoder. A good source of stable and accurate RTTY can often be found on parts of the two metre amateur band. These signals use audio frequency shift keying (AFSK) and are transmitted using FM. Most capital cities now have dedicated RTTY repeaters on the two metre band and these are an excellent source of good signals.

With a good RTTY signal applied to the decoder, you can adjust the trimpots either by observing the output of the XR2211 on an oscilloscope or by examining the output on the printer for errors. It should be noted that most amateur RTTY transmissions use the 170 Hz shift standard and are transmitted at 45.45 baud. To align the wide shift RTTY part of the decoder, a good source of 850 Hz shift RTTY will be needed. This may prove a little difficult as most users of this standard are commercial stations using FSK on the HF bands which require the SSB mode to resolve.

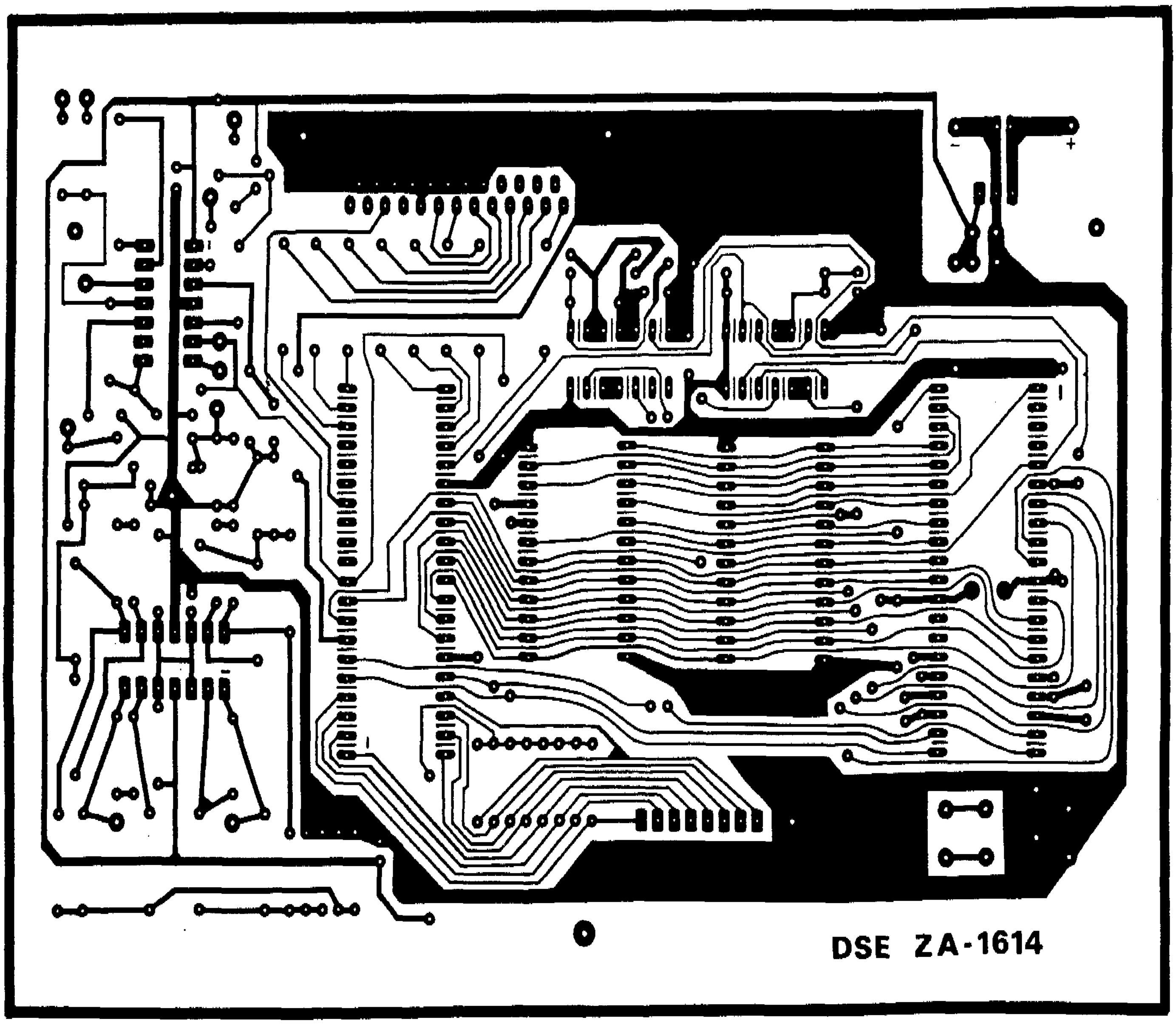
Using your decoder

Operation of the decoder is quite straightforward. In the Morse mode, the tuning control on the front panel is used to tune the decoder into the pitch of the received signal. When correctly tuned, the front panel LED will flash in time with the received DITs and DAHs. Don't expect to get perfect, error free reception of Morse code, as much will depend on the characteristics of the transmitted signal. Morse which is sent by hand does not always adhere to the correct element spacing and even the best decoder will become confused by a sloppy operator.

RTTY reception should initially be tried on strong signals such as those found on the amateur two metre band around 146-147 MHz FM. In this mode, the front panel LED will show "in lock" when correctly tuned, indicating that the received tones are within the range set by SW1. As mentioned before, most amateur RTTY is transmitted using the narrower shift and at 45.45 baud.

Once correct RTTY operation has been verified, you can try the decoder on some signals on the HF bands. A good place to start looking for narrow shift amateur signals in in the 20 metre band between about 14 060 kHz and 14 100 kHz. If you only seem to get garbled text, you could try setting the "invert/normal" switch to the other position or try other baud rates. After becoming familiar with the operation of the decoder, you will quickly be able to estimate the correct settings by the sound of the signal.

If you are attempting to receive commercial RTTY stations, remember that a few of these use some method of encryption to prevent unauthorised eavesdropping. There isn't much you can do about these stations as all settings on the decoder will produce meaningless printouts. For some useful information on where to look for interesting RTTY signals on the HF bands, you could refer to the article "A Guide to non-voice transmissions on shortwave" by Roger Harrison VK2ZTB, which was published in the July 1987 issue of Australian Electronics Monthly.



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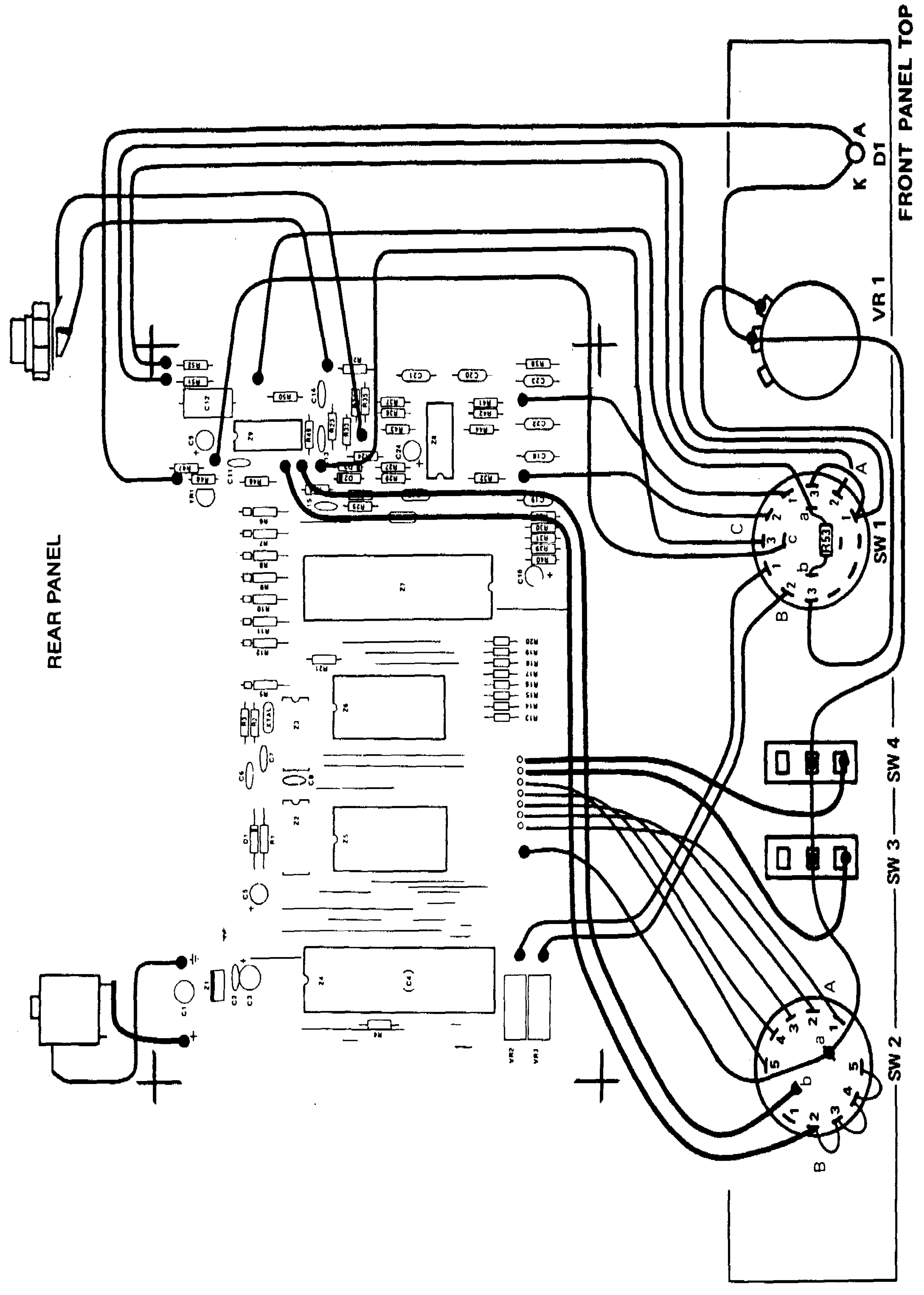
Wiring Diagram



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Notes & Errata

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welcome here

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TUNING MORSE

When tuning the unit in the Morse mode, problems can arise with a very noisy Morse signal. Errors in reception might be observed as 'E's resulting from the tone detector being triggered by a burst of noise. These errors can be reduced well by the following two methods.

The first is to be careful not to put too high a signal level into the unit. As the signal level into the Decoder increases so too does the noise between the Morse elements. After a certain level, the noise present will start to trigger the tone detector and contribute a large number of random pulses amidst the Morse signal. The best way of avoiding this is to be able to adjust the signal level from the receiver into the Decoder. The signal level should be reduced so that random flickering of the in-tune LED is minimized.

The second method is to increase the pitch of the Morse signal by de-tuning the VFO of the receiver slightly. This will require that the TUNE knob is increased clockwise for a higher tone, but will allow better discrimination to be made by the tone detector.

When Morse is being received and decoded, for minimum errors the 'in-tune' LED should be seen to be flashing exactly as the Morse tone is being heard. Spurious flashes when the tone is off, or flickering when the tone is on, suggests that either the noise level is too high or the unit is not tuned well to the Morse tone.

Notes & Errata

1. Upon power-up the message "K-6339 Morse/RTTY Decoder" is sent to the printer as a sign-on message and confirmation of correct reset.